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Spatial Nucleation and Crystal Growth

J. B. Hudson

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Department of Materials Engineering
Rensselaer Polytechnic Institute
Troy, New York

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Introduction

This report summarizes the progress of research efforts under NASA Grant NsG-663 during the six-month period from December 1965 through May 1966 inclusive. The central aims of this grant are to obtain experimental information pertinent to the process of particle formation under the conditions extant in interplanetary and interstellar space, and to use this experimental information to formulate a coherent theory of the origin of such particles.

Progress to Date

During the present period, the measurements of the nucleation of selenium on glass were completed. The significant results of the study are summarized briefly below:

1. In the static vapor case, the phase nucleated was inevitably the liquid, even at temperatures as much as 100°C below the equilibrium melting point.
2. In the molecular beam case, only the red solid phase was nucleated, even at substrate temperatures and effective impingement rates identical to some of those used in the static vapor experiments.
3. Both sets of results show the same qualitative dependence of the critical supersaturation on temperature as was observed previously for zinc and cadmium. This temperature dependence indicates a low temperature region which is in qualitative agreement with existing nucleation

theory and a high temperature region for which there is no agreement with theory.

4. It appears on the basis of the above observations that the change in morphology of the nucleated phase with experimental conditions is due to impurity adsorption on the substrate in the static vapor measurements.

Recently, the results to date were embodied in a seminar presented to the Materials Science and Engineering Division, The Franklin Institute Research Laboratories, Philadelphia, Pa. The final results are currently being prepared for publication.

The system designed to measure the thermal accommodation and condensed phase nucleation of mercury or glass has been rebuilt to permit operation at a higher signal-to-noise ratio, and is currently being tested. Initial results indicate that the redesign has improved the signal-to-noise ratio significantly. In addition, the system has been modified so that nucleation and thermal accommodation data can be obtained in the same experimental run.

The mass spectrometer system was tested using the electron gun in an attempt to effect electron bombardment desorption of gases adsorbed on a rhenium substrate. The experiment failed because of inadequate electrical shielding between the electron gun, mass spectrometer and system walls. The system is currently being redesigned to eliminate this problem.

Further consideration of the study of homogeneous nucleation using the adiabatic flow in a supersonic nozzle has led to the decision to go ahead and build a system in which such measurements can be made. This system is currently being designed.

A review article on the nucleation and growth of crystals, from the vapor, with special emphasis on growth under conditions of astrophysical significance has been started and carried about halfway through a first draft. This article is being prepared for inclusion in a pending monograph on astrochemistry.

Prognosis

During the next reporting period, the selenium work will be written up and submitted for publication. Measurements of thermal accommodation and nucleation of mercury on glass will be made. The mass spectrometer system will be rebuilt to permit the desired electron desorption measurements. Construction and test of the supersonic molecular beam system for homogeneous nucleation measurements will be begun. The review article on nucleation and growth will be completed.